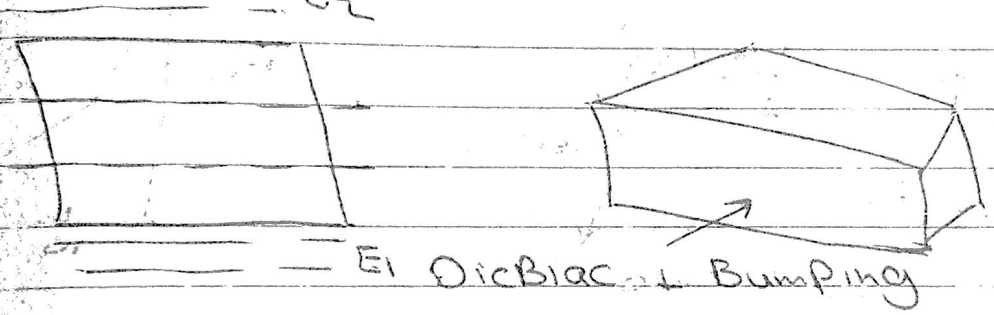
lec (13)

$P_e = e^{-h\nu/kT}$ At thermal Equilibrium.

Prob of emission at Quassi equilibrium

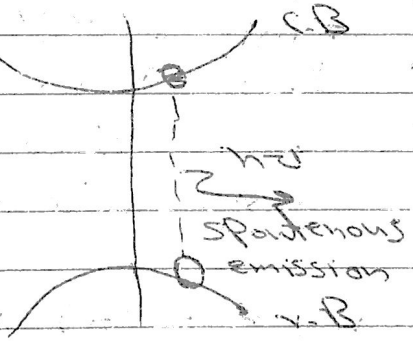


$f_e(E_2)\left[1 - f_v(E_1)\right]$

$$\left[1 - \frac{1}{e^{(E_1 - E_{fv})/kT} + 1}\right]$$

$$\frac{e^{(E_1 - E_{fv})/kT}}{e^{(E_1 - E_{fv})/kT} + 1}$$

$$\frac{1}{e^{(E_2 - E_{fc})/kT} + 1}$$



Apply Boltzmann Approx

$(E_2 - E_{fc}) \gg kT$

$|(E_1 - E_{fv})| \gg kT$

$$= e^{-(E_2 - E_{fc})/kT} \cdot e^{(E_1 - E_{fv})/kT}$$

$$e^{-(E_2 - E_1)/kT} \cdot e^{(E_{fc} - E_{fv})/kT}$$

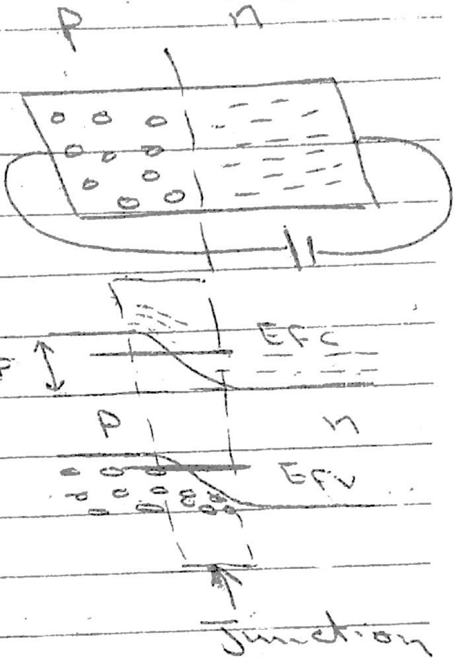
P_e

$P_e = e^{-h\nu/kT}\, e^{(E_{fc}-E_{fv})/kT}$ $\qquad E_{fc} > E_{fv}$

GaAs

لزيادة الاشعاع مثلا

نحضر p n ونعمل
Junct
Forward Bias



Rate of spontenous emission
أي إشعاع

$r_{sp} = \frac{1}{\tau_r}\, \rho(\nu)\, P_e$

$\rho(\nu)$ = optical joint Density
τ_r = time of Recombination

No of emitted Photons per unit time per unit volume per unit energy (freq)

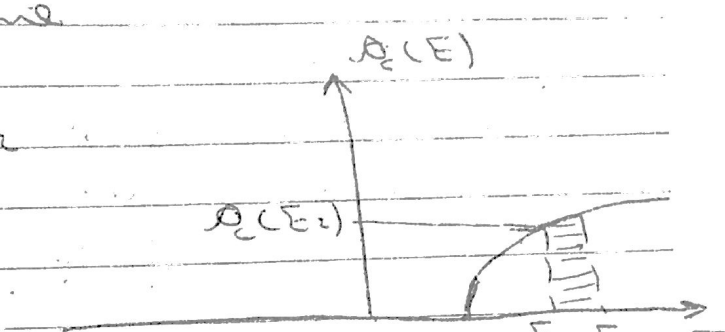
$\rho(\nu)$ → N.o of emitted or absorped Photon per unit volume per unit energy

2

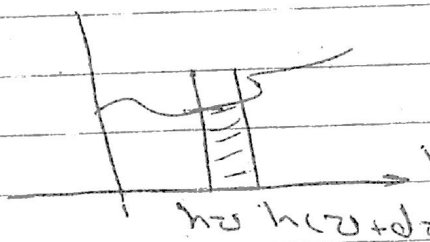
joint → 2 allowed states   ناتجة لانتقال بين
بين ال valan و ال cond

No of allowed states $(E_2 \rightarrow E_2 + dE_2)$ per unit volume

$= \rho_c(E_2)\, dE_2$



$\rho(\nu)\, d\nu$ ← Freq, ↑ Per unit volume



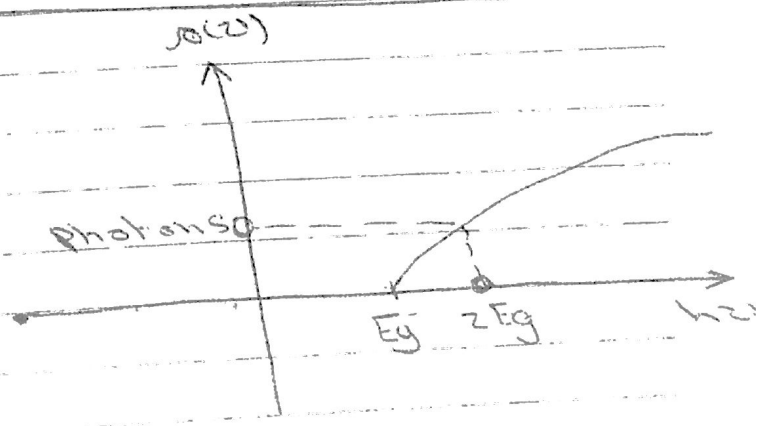
$$\rho_c(E_2)\, dE_2 = \rho(\nu)\, d\nu$$

$$\rho(\nu) = \rho_c(E_2)\, \frac{dE_2}{d\nu}$$

$$\rho(\nu) = \frac{1}{2\pi^2}\left(\frac{2mc}{h^2}\right)^{3/2} (E_2 - E_c)^{1/2} \cdot \frac{mr}{mc} \cdot h$$

$$\left(\frac{mr}{mc}\right)^{1/2} (h\nu - E_g)^{1/2}$$

$$\boxed{\rho(\nu) = \frac{1}{\pi h^2}(2mr)^{3/2}(h\nu - E_g)^{1/2}}$$



$$R_{sp} = \frac{1}{2\pi\hbar^2}\left(\frac{2m_r}{r}\right)^{3/2}(-E_g + h\nu)^{1/2} e^{-h\nu/kT}$$

↳ rate of spontaneous emission at thermal equilibrium

Quassi eq gt

$$R_{sp} * e^{(E_{fc} - E_{fv})/kT}$$

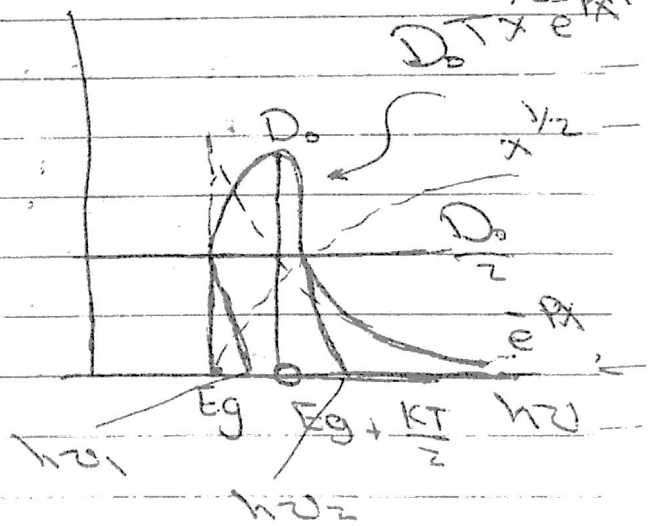
$$R_{sp} = \frac{1}{2\pi\hbar^2}(2m_r)^{3/2} e^{-E_g/kT}\left[(h\nu - E_g)^{1/2} e^{-(h\nu - E_g)/kT}\right]$$

$$R_{sp} = D_o T x^{1/2} e^{-px} \qquad p = \frac{1}{kT}$$

$\frac{dR_{sp}}{d\nu} = 0 \rightarrow [h\nu]_p$

$= E_g + \frac{kT}{2}$

$D_o T x^{1/2} e^{-px}$



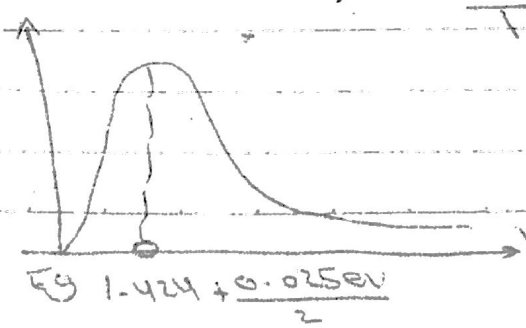
half Power Beam width

$\lambda = 1.45\, kT\, \lambda^2$

$\nu = 1.45\, kTc$

x):- GaAs $E_g = 1.424$ eV

$T = 300^\circ k$



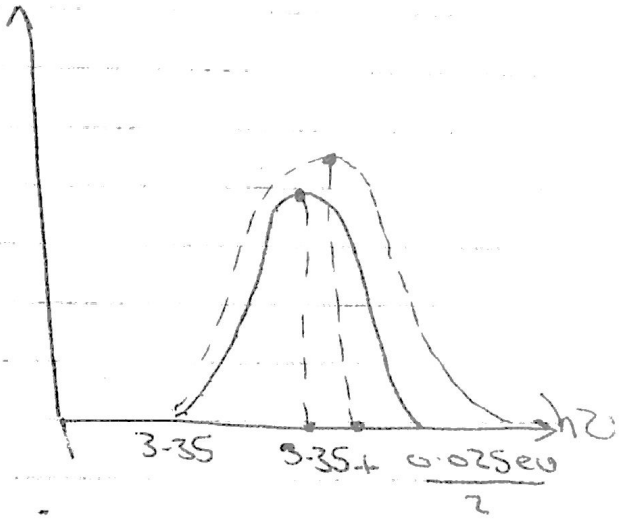
Subject :

Date :

GAN $E_g = 3.35$ eV

T ↑ Q ↑

$Q_o(T)$ ↑ BW ↑



شروط نوع إشعاع من الليزر

1. Semicond Direct mat
2. Bumbing Forward Bias